Policy support strategies for the adoption of information and communications technology

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3 Policy support strategies for the adoption of information and communications technology

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3.1 Introduction

Technology policy has traditionally focused mainly on entrepreneurial invention and innovation of new technologies, but several recent studies have also stressed the importance of government support in the adoption and diffusion of innovations (see, e.g. Stoneman and Diederen 1994). The market for information and communications technology (ICT) provides a good example of a sector whose supply side is very innovative and rapidly progressing and which hardly requires any further public support for its R&D activities. The demand for ICT, instead, seems to suffer from several inefficiencies, while the spread of ICT follows spatially highly uneven diffusion patterns. This contribution focuses on essential features of the market for communications services and technologies from the adopters' point of view. We will discuss in particular the decisive factors affecting a firm's adoption decision regarding new communications technologies, market imperfections on the ICT market and their implications for public policy. The role of interfirm dependence (or network externalities) and of several sources of uncertainties in the diffusion of communications technologies will be emphasized. It seems plausible that interfirm connectivities and uncertainties may give rise to prominent inefficiencies in the dynamics of interfirm network formation and behaviour.

The rationale for supporting the diffusion of ICT is largely based on the assumed positive relationship between ICT investments and economic growth (see, e.g. The World Bank 1994). But there are several ways investments in communications networks and infrastructure may contribute to economic growth. First, both private investments in communications technologies and public infrastructure investments may accelerate economic growth by increasing the productivity of firms involved and by reducing their transaction costs. Improved communication capacities and communication abilities may also enhance or at least improve and increase the

efficiency of both intrafirm and interfirm communications (see Capello 1994, or Capello and Nijkamp 1996). This observation applies not only to buyer-seller relationships, but also to forms of communication that are not directly related to market transactions, for example, to disjoint R&D units of multinational companies and to joint research ventures of different firms.

Second, communications networks may also enhance economic growth by promoting the firms' innovative behaviour. The adoption and use of communications network may lead to further adoption of organizational innovations (like just-in-time systems) and potentially also to the reorganization of a firm (see Gillespie 1993 for a detailed discussion on the topic). Also, the utilization of information and communications technology may help firms, for instance, to coordinate their international R&D activities, to avoid duplication of research efforts and to improve their efficiency in terms of both communication and money spent on R&D (see Howells 1995). Consequently, information and communications networks – if fully utilized – may not only facilitate economic growth, but also generate positive innovative effects on the economies as a whole.

Via the linkage of communications networks to intrafirm cooperation and to the research and development efforts of firms, the implementation of technology policies can have significant long run economic effects, far beyond the network markets as such.[1] Entrepreneurial adoption and utilization of advanced communications technologies is a prominent potential source and accelerator of techno-economic development and may help removing or alleviating inefficiencies. The aim of this contribution is to highlight *potential sources of inefficiencies arising at the demand side of the network markets* and their consequent *implications for the implementation of adoption policies on the ICT market.*

In Section 3.2, we will briefly discuss the forms of advanced communications services, technologies and networks the ICT market provide for intrafirm and interfirm communication. Section 3.3 highlights the crucial factors affecting the adoption behaviour of economic actors in ICT networks which may potentially create inefficiencies in the network market. The implications of these factors for the technology policies practiced is discussed in Section 3.4. We will also discuss several problems which may emerge in the practical implementation of technology policies on the network market. In Section 3.5, we will conclude our discussion with some final remarks on the need for government actions on the ICT market.

3.2 Communications networks and services

Tremendous technical progress in information and communications technologies and a consequent increase in the capacity of telecommunications networks to transmit data and information has led to the development of a great number of new communications services. The communications networks embrace not only services which allow direct connection between the users (e.g. EDI and e-mail), but also services which do not involve personal communication (for example,

electronic databases). The former service type is typically based on the reciprocal communication possibilities which means that it is feasible to transfer information or to communicate towards both directions in a network. The latter category of services comprises both reciprocal services (e.g. possibilities to export files and to do electronic shopping) and non-reciprocal network services (for example, information services).

Communication services differ not only in – and in fact, due to – the direction of information transfer or communication, but also in the type of interdependence between the network users. Services used for personal two-way communication embrace direct user interdependence or direct network externalities (see, e.g. Capello 1994 for a discussion of network externalities). This means that the benefits for the service subscribers depend directly on the number of network users. When crowding is not a problem, we may safely assume that the benefits for the existing users will increase with the additional users or direct contacts via a network, i.e. the externality is positive. Communications services which do not provide direct contacts between the users exhibit indirect externalities: the variety of services supplied in a network increases with the number of network users.

Also the networks can be subdivided into two categories according to their reciprocity: reciprocal networks are called two-way networks, whereas non–reciprocal networks represent one-way networks (see Economides and White 1994). Communications networks belong typically to the category of two-way networks and consequently involve direct network externalities. One-way networks, instead, – like the Automated Teller Machine (ATM) networks – exhibit indirect network externalities among the users of a network. The interdependence of network users – whether it is direct or indirect – highlights the importance of the compatibility of complementary technological components in a network.

The modern information and communications technologies currently provide a wide variety of divergent means for interfirm and intrafirm communications. Table 3.1 presents various examples of the possibilities offered by modern information and communications technologies (ICT) for transmitting text, voice, moving picture, graphics and/or data. This list of information technology media gives a description of some common forms of ICT used at present, but is by no means exhaustive. Due to the rapid progress in the microelectronics and communications technologies, new equipment and services are frequently and uninterruptedly introduced on the ICT market.

In addition to the capacity of communications media to transmit different forms of data or information, these media or network services also differ with respect to various other important properties which affect a firm's decision to adopt a certain technology from among the communications technologies or services supplied on the ICT market. A communications technology may enable one-way or two-way communications, while it may be either real time (or on-line) – that is, a person who receives a message/picture, can read/see it at the moment it is transmitted – or alternatively the service can be on-line which means that there is a delay between the transmission and reception of a message. Also, the interaction level of

communication varies with the service types: some technologies can just be used for bilateral communication, whereas others allow that more than two users participate in an interaction. For instance, the user of a business TV can transmit voice, picture and graphics simultaneously to several locations, but the receivers of this transmission cannot respond to the transmitter via the the same media. Some complementary media – for instance, a telephone – is needed, when the users of business TV require two-way communication possibilities. Especially the large companies have used the business TV for their intra-firm communication and for the training of their employees.

Table 3.1

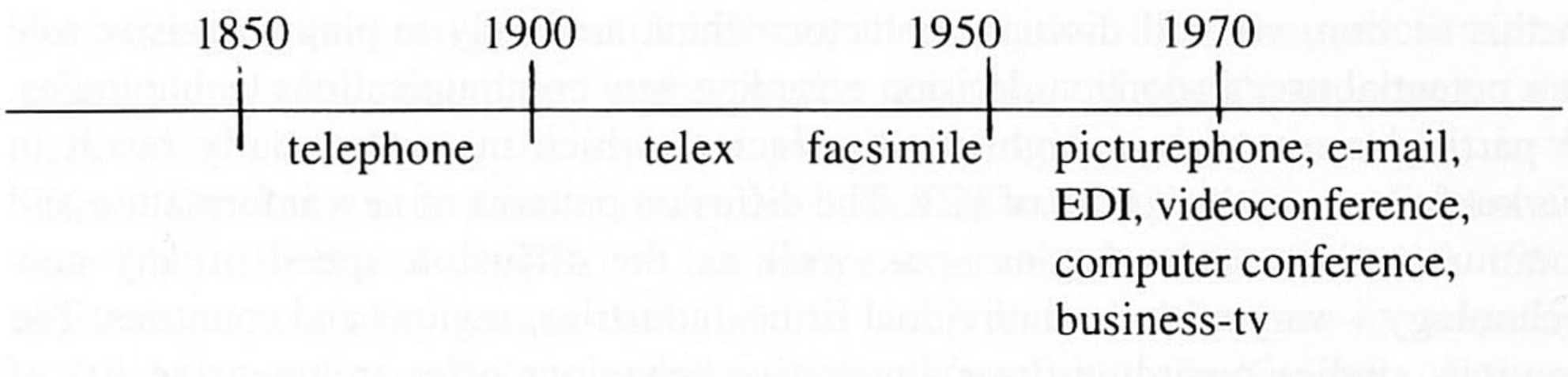
The forms of ICT for communication and data transfer

Media	Commu-nica-tion	Real time	Interaction level	Capa-city for trans-mis-sion				
	One-way/ two-way	On-line/ off-line	Bilateral/ multilat - eral	Text	Voice	Mov-ing picture	Gra-phics	Data
Telephone	Two-way	On-line	Bi-/multila-teral		x			
Fax	Two-way	Two-way	Bilateral	x			x	
E-mail	Two-way	Off-line	Bilateral	x			x	x
Electronic Data Interchange (EDI)	Two-way	Off-line	Bilateral	x				x
Picturephone	Two-way	On-line	Bi-/multila-teral		x	x	x	
Video conference	Two-way	On-line	Multilat-eral	x	x	x	x	x
Computer-conference	Two-way	On-line	Bi-/multila-teral	x			x	x
Business TV	One-way	On-line/ off-line	Multila-teral		x	x	x	

Source: Himanen et al. (1993).

We may also consider communications technologies by their years of introduction or when these technologies came available on the market (see Picture 3.1). The evolution of communications technologies began in 1877 when the telephone was introduced. During (almost) the next hundred years, relatively few new communications technologies were introduced - of which most important were perhaps telex (1920) and facsimile (1930) - on the market. The late 60s and early 70s marked a turning point in the evolution of information and communications technologies. The advances in microelectronics and computer technologies led into the development of a wide variety of new forms of communications, like computer conferencing and e-mail. Picture 3.1 sketches only few examples of new communications technologies introduced after 1970. During the past two decades the market for information and communications technologies has witnessed an explosion of new communications media.

Picture 3.1
Evolution of communications technology



Communications networks can also be mutually distinguished according to the types of physical connections between the nodes of a network in the following way (Bosilani et al. 1994): (i) Local Area Networks (LAN), (ii) Private Wide Area Networks (Private WAN), (iii) Public WAN and (iv) Third Party Networks or Value Added Networks (VANs). Local Area Networks are typically privately owned interfirm networks for which the user organization of a network assumes full responsibility. Spatially, LAN is typically used for intrafirm communication and covers a building and sometimes, in addition, some of its surrounding buildings. Wide Area Networks, can be either publicly or privately owned and the users' responsibilities are often restricted to the end systems which access the network or to the operations and management of communications. The users of WAN can spatially be more dispersely located than the users of LAN; WAN can be used for intrafirm relationships or for connecting the distant business units of a single firm. Third Party Networks – which are typically owned by the telecommunications operators – may provide a multitude of divergent services, for instance, EDI and databanks.

In addition to the criteria mentioned above, there are some other features which may be used for categorizing the different types of communications networks. These include, for instance, the logical structure of a network, the hardware devices

supporting information exchange and the communication language (see Bosilani et al. 1994). When discussing communications networks we cannot avoid referring to a gigantic worldwide network of the networks – Internet – which may include any of the communications networks mentioned above, irrespective of the category a communications network belongs to (see MacKie-Mason and Varian 1994 for a discussion of the economics of Internet).

This brief discussion on the communications technologies and networks indicates that the current market offers extensive possibilities for advanced intrafirm and inter firm communication by ICT. However, the spread of the new communications technologies in the economy does not necessarily follow optimal diffusion patterns from the society's point of view; the market for information and communications technologies involves several features which affect the adopters' behaviour and may result in inefficiencies in the diffusion of ICT. We will now discuss these features and the possible adoption behaviour of economic actors in the next section.

3.3 Adopters' behaviour in communications networks

In this section, we will discuss the factors which are likely to play a decisive role in a potential user's adoption decision regarding new communications technologies. In particular, we aim to highlight the factors which may potentially result in market failures in the spread of ICT. The diffusion patterns of new information and communications technologies – as well as the diffusion speed of any new technology – vary with the individual firms, industries, regions and countries. The previous studies regarding firms' innovative behaviour offer an extensive list of potential factors which may affect entrepreneurial innovative behaviour in general (see, e.g. Fischer 1995). A firm's adoption of a new technology or innovation may depend, for instance, on various firm-specific factors: e.g. firm size and ownership structure (Rose and Joskow 1990); locational factors, e.g. a firm's distance from the central or metropolitan area (Davelaar and Nijkamp 1988); techno-economic factors, e.g. the industrial sector a firm belongs to (Kamann and Nijkamp 1990); and the political-institutional context, e.g. laws and regulations (Riordan 1992).

The underlying factors which determine the spread of new communications technologies differ in some respects from the factors affecting the diffusion of non–network technologies and innovations in general. The most striking features distinguishing the market for communications technologies from the non-network market originate from – both direct and indirect – user interdependence and from the coincident occurrence of both substitutes and complements – which may further be compatible or incompatible – on network markets. Consequently, the existence of network externalities is one potential source of market failure in the network market (see, e.g. Capello 1994; Farrell and Saloner 1986; Katz and Shapiro 1986). Some other forms of market imperfections which may emerge on the ICT market are asymmetric information, several sources of uncertainties, and the existence of

monopolistic and monopsonistic powers.[2] We will next discuss these properties and their implications for the adopters' behaviour on the network market.

We distinguish the following two types of interdependencies among economic actors, who consider the adoption of new communications technologies: (i) *static or cross-sectional externalities* and (ii) *dynamic or sequential or adoption externalities*. Static externalities refer to a variety of interdependencies which emerge within a certain period among the current users of a technology. The types of interdependencies we incorporate into the definition of static externality are consumption externality, technical externality, pecuniary externality and indirect externalities. The first type of externality concerns only consumers, whereas the second and the third one relate to the entrepreneurial adoption behaviour. Indirect network externalities may benefit both the firms and the consumers. The more a potential user of a certain communications technology values direct externalities or a variety of network services, the more determinant is the expected order of magnitude of static externalities in his adoption decision.

The market for communications technology exhibits also dynamic or sequential externalities, which reflect an intertemporal dependence of economic actors and which are related to the timing of adoption of new technologies. Due to the presence of static network externalities, the adoption behaviour of firms and consumers is influenced not only by the decisions of earlier and current user generations, but also by the expected penetration rates of the technologies in the future. Dynamic externalities comprise backward externality, forward externality (see Choi 1994) and competitive advantage externality (see Kamien et al. 1992). Backward externality means that the late adopters may adopt an incompatible technology with the early adopters and then strand them inefficiently. Forward externality implies that some actors rush to adopt a new technology inefficiently early from the society's point of view and in consequence, it is possible – if the technologies are incompatible – that an inferior technology may become a standard due to the benefits arising from the use of compatible technology with the early adopters.

Backward and forward externalities may not only take place in the spread of a technology among the firms, but also in the diffusion process taking place among consumers. Competitive advantage externality, instead, relates only to the dynamics of the firms' investment behaviour. Competitive advantage externality means that the spread of a new technology may be inefficiently slow from the society's point of view, when the firms realize that – in addition to the competitive advantage the technology possibly provides – the adoption of a new technology may benefit also their rivals. If a firm adopts a new technology before its rivals, the rivals can then possibly adopt the technology with lower costs and/or be able to make a better choice among the technologies due to information which spills over from the early adopters to the later user generations.

As the use value of a communications technology is highly dependent on the number of other users in a communications network, the size of *an installed user base* of a technology is likely to be one of the key factors in the adopters' ICT

investment decision (see for an extensive discussion of the subject, e.g. Farrell and Saloner 1986). Then, *the (private) critical mass of users* – that is, the smallest user size at with a user is indifferent to adopting and not adopting a new network technology – plays a prominent role in network dynamics (see, e.g. Economides and Himmelberg 1995; Heal 1990 and Koski 1995a). This hypothesis is also supported by some empirical evidence. The empirical exploration of Koski and Nijkamp (1996a) points out that the probability of early adoption of ICT decreases, when the minimum number of business partners a firm requires to use ICT before it adopts ICT increases. Their study further supports the presence and significance of network externalities in the entrepreneurial adoption of new communications technologies.

Inefficiencies in the diffusion of communications technologies may arise directly from the presence and value of positive externalities in the networks via the size of an installed user base. During the early phases of a network, when the network size is small, the diffusion of a new technology may be inefficiently slow. In particular, when the critical mass of users is not reached in a network, the potential of positive network externalities in the network is likely to be underutilized.

Dynamic externalities imply that the adoption of a new communications technology involves *uncertainty* related to the other actors' adoption behaviour. This uncertainty may originate from the uncertain profitability of a new technology or technologies (see, e.g. Jensen 1984, 1992) as well as from the timing and significance of future improvements in the technology (see, e.g. Rosenberg 1976). Consequently, economic actors do not know for sure what the size of a network or the number of the users of a certain technology will be in the future. The importance of the composition of network subscribers – that is, the share of the firms' business partners and rivals in a network – may vary with the firm's investment strategy and position in the market. These uncertain aspects concerning the new communications technologies highlight the key role *expectations* play in the evolution of networks.

The presence of uncertainty may have significant implications for the investment behaviour of economic actors, when the investment incorporates sunk costs or irreversibility (see, e.g. Dixit and Pindyck 1994). This condition certainly applies to a new communications technology: typically the retail price of information technology falls greatly short of its purchase price and, in addition, the use of a new communications technology requires substantial and (at least partly) unrecoverable learning costs. Uncertainty reduces the expected value of a technology and consequently, the potential investors may prefer an option to wait and reduce uncertainty by gathering more information regarding a new technology to the adoption of the technology.

Several sources of uncertainties regarding new network technologies stress the role of *risk behaviour* and expectations of economic actors in the diffusion process of a new technology. Some previous theoretical and empirical studies suggest that a coincident presence of network externalities and uncertainties can have clear implications for the adoption of the new communications technologies and

consequently, for the diffusion speed of these network technologies.[3] The presence of uncertainties and the actors' reluctance towards undertaking risky network investments may result in an inefficiently slow dispersion of a new technology (Koski 1995a). Choi (1994) points out that due to the dominance of forward externality over backward externality, the early adopters may adopt a new network technology also too early from a society point of view. Some other factors which affect the diffusion process of a network technology or the timing of adoption of a network technology are the size of an installed user base of a network technology (Farrell and Saloner 1986), the order of magnitude of scale economies in the production of a new technology and information spillovers regarding the new technology (Koski and Nijkamp 1996a).

The actors' expectations regarding the new information and communications technologies and networks may be one of the central factors determining the diffusion speed of ICTs. Despite that, recent literature does not provide much empirical evidence on the role of expectations in network dynamics. The study by Koski and Nijkamp (1996a) suggests that at the same time when the low number of network users hinders the diffusion of new communications technologies – especially in the early phases of the network - *the expectations on the network size in the future* are of great importance in the adoption decision of a potential user. Higher expectations on the diffusion of a new communications technology among the firm's business partners seem to facilitate the early entrepreneurial adoption of the technology.

Another inefficiency which may emerge due to the presence of uncertainties and externalities is the adoption of an inferior technological *standard*, even if the network market would be able to offer a superior one. The higher the risk aversion of economic actors or the higher the uncertainty related to a new network technology, the higher the private critical mass and the later a technology will be adopted by economic actors. Then, it is possible – especially when a considerable share of the user value of a technology is composed of the external benefits which can only be achieved if the other users join a network – that a new superior technical standard will never be adopted.

The issue of standards and the *compatibility* of technological components in networks have received considerable attention in the recent economic literature (see, e.g. Besen and Farrell 1994; Church and Gandal 1992; Farrell and Saloner 1985 and Katz and Shapiro 1986). For instance, Church and Gandal (1992) provide an interesting study on the implications of actors' preferences and behaviour regarding the optimal amount of standardization on the network market. They investigate the equilibrium supply conditions for the network technologies when the technologies (hardware) have no value per se, but in their analysis, the demand is completely determined by the availability and variety of compatible software products. In this case, the decisions of software producers regarding the question which network they join – that is, with which hardware they produce compatible software products – can have significant consequences for the number of divergent hardware technologies supplied. The study by Church and Gandal indicates that the market

may produce a suboptimal amount of standardization, when consumers place a high value on the variety of software products. There is also some empirical evidence that indicates that the diffusion speed of network technologies may be critically affected by the (in)compatibility of an installed base of a network technology (see Koski and Nijkamp 1996b). For example, data from the European microcomputer market suggests that the higher the degree of compatibility of microcomputers sold, the higher the diffusion speed of microcomputers in the aggregate.

It is also noteworthy that the evolution of networks may be affected by *the strategic investment behaviour* of economic actors (Preißl 1995).[4] Some forms of strategic adoption behaviour are related to the early adoption of a new communications technology, whereas other behaviours may result in waiting and a later adoption of the technology (see, e.g. Freeman 1982 and Karlsson 1995 for a discussion on the topic, and Koski 1995b for some empirical evidence of adopters' strategic behaviour in networks).[5] The adoption of a new technology may be related to the aggressive investment behaviour aiming at cost reductions and efficiency gains by the use of a new technology and consequently, to the competitive advantange on the market a firm sells its own production. Another strategic reason for the early adoption of a technology may be a firm's intention to achieve *market power* by a successful network investment. The objective of the early adopter of a new communications technology may be to increase its monopolistic power on its production market or to strengthen its monopsonistic power on the market for intermediate products or resources. Later adopters, instead, may benefit from the reduced uncertainty regarding a new network technology via information which spills over from the early adopters of a technology.

Also *asymmetric information* between the economic actors and regions may result in inefficiencies on the network market. The previous literature suggests that there are considerable informational asymmetries between metropolitan and peripheral areas and that the firms' innovative behaviour is likely to differ among different regions and tends to favour the generation and adoption of innovations in the central areas (see, e.g. Hägerstrand 1967; Kamann and Nijkamp 1990). Some recent studies also provide some evidence for the existence of highly uneven diffusion patterns of information technology between central and pheripheral regions (see Antonelli 1990): the more advanced, central regions tend to adopt new information technologies faster than the remote ones. Information regarding the new technologies may be available earlier in central areas than in pheripheral regions and, moreover, the firms' capability to utilize these network technologies may also be higher due to, for instance, more skilled labour force in the central regions. Consequently, as information reduces uncertainty, especially the pheripheral regions are the ones which are likely to suffer from these inefficiencies hindering the diffusion of advanced communications technologies. This is quite paradoxical, since the pheripheral areas might be the greatest beneficiaries of the new communications technologies which provide access to timely information and to the multitude of services regardless of the geographical location of a user.

These inefficiencies highlight the importance of government intervention and the policy makers' role on the network market. In the next section, we will discuss practical technology policies regarding communications technologies and networks and some problems related to the implementation of these policies.

3.4 Policy implications of the adopters' behaviour

As technology policy exercised by the government ultimately creates the rules and legal framework for innovative behaviour and may have a significant impact on the firms' incentives to generate and adopt innovations, we will in this section discuss the implications of the adopters' behaviour for public policies on the ICT market. Mowery (1995) considers a set of practical technology policy strategies which can be used for influencing the demand for new technologies. He distinguishes these adoption oriented technology policies by using the following five main categories:

i financial subsidies for adoption of new technologies;
ii information provision programmes;
iii technical standards;
iv government mandated technology transfer from foreign sources and;
v government procurement.

We will next use this framework for a discussion on the implications the adopters' behaviour on the network market may have for the practical adoption or diffusion oriented network policies. Also, we will discuss some related problems which may emerge in the practice of technology policies regarding communications technologies and networks.

3.4.1 Subsidies as a means to promote the diffusion of communications technologies

The presence of the great many uncertainties and network externalities related to the use of communications technologies and networks suggests that subsidies may be one of the suitable policy means for encouraging the early users to adopt and utilize advanced communications technologies. As Mowery (1995) points out:

> 'The economic justification for subsidies must be based on the uncertainties and limited information faced by early adopters, as well as imperfections in the capital markets available to small firms. If a new technology is characterized by important network externalities, or if the rate of adoption for other reasons accelerates as a function of the number of adopters (e.g. reductions in uncertainty because of better information through widespread use), subsidies to early adopters may be justified.'

In general, the adoption of a network technology needs to be subsidized until the installed base of the users of the technology is sufficiently high, such that the diffusion of a new technology proceeds by the market mechanism and the network will not collapse. In practice, this critical network size is extremely difficult if not impossible to determine correctly, and consequently, policy makers may find it hard to decide on the correct amount of subsidies needed or when they should withdraw from subsidizing the adopters. This task, the evaluation of the divergence between the private and social rates of return, is further complicated by the presence of external benefits whose volume or value to the users is not only unknown to the decision makers but probably also to the potential users themselves.

Besides the proper order of magnitude of subsidies, also several other problems are related to the use of subsidies for facilitating the dispersion of new network technologies (see Geroski 1995 for a discussion on the problems related to subsidizing the firms' R&D investments). Asymmetric information between public authorities and subsidized enterprises may give rise to moral hazard problems: the enterprises may abuse allocated funds by using them for purposes other than those initially aimed at. The misuse of subsidies may be intentional, but it may also happen when the structure of financial subsidies or tax reliefs for entrepreneurial investment in communications technologies fails to meet its target. For instance, pure monetary support for network investments may result in investments in information capital and communications technologies in the firms, but does not necessarily lead to the maximum exploitation of these technologies. An extensive utilization of the new communications technologies is likely to require a substantial learning process. Then, it is possible, when the subsidies do not induce the firms to invest in the training of their personnel, that the adopted technologies will be underutilized due to the lack of capability of the firms' staff to use them. This underinvestment can have remarkable consequences, since the behaviour of a single actor in a network can affect, besides its own performance, also the functioning of the other actors in the network.

3.4.2 Information provision and support for technical training

As information regarding a new technology and its exploitation in entrepreneurial environment are preconditions for the productive use of communications technologies and networks, information provision programmes can play a decisive role in the diffusion and utilization of advanced communications technologies. These programmes can be used both for reducing uncertainty regarding ICT, but also for diminishing information asymmetries which may emerge between the different regions and firms. The existing evidence of uneven diffusion of information technology between the central and pheripheral regions suggests that the information provision programmes should emphasize the dissemination of information of new technologies to the firms located in remote areas.

Direct financial support for the firms' capital investments in network technologies is an improper policy means among the industries or regions, where

the firms would invest in the new technologies in any case (see Metcalfe 1995) and probably an insufficient means in many cases, even if the direct monetary subsidies were needed. The goal of public ICT supporting programmes – the widespread adoption and utilization of advanced communications systems – might be reached (or at least approached) both by providing information on technological possibilities and by supporting the introduction and use of new systems in the firms. In addition to direct financial subsidies, the public programmes might support the utilization of communications technologies in networks by providing assistance in the training of the firms' personnel and also by encouraging cooperation among the enterprises in the network formation.

3.4.3 Standards in the networks

Due to the presence of network externalities and uncertainties, the specification of unambiguous standards are of utmost importance in communications networks. The maximum exploitation of network externalities related to the use of information and communications technologies can be achieved only by proper standardization policies. This task is, however, by no means easy; there are several problems which may complicate the standardization efforts. We will next briefly discuss the difficulties which may relate not only to the ICT market, but also directly to the economic decision makers who are responsible for practical technology policies.

Ongoing liberalization of the telecommunications market results in an increase in the number of players in the competitive field. Although this tendency towards competitive markets may be healthy, it can also have some negative side effects which complicate the setting of standards in the network market. The global telecommunications market based mainly on national monopolies has also involved some positive features: the relatively small number of actors in the world communications market. The gradual technical change and consensus on the techinique and nature of the public services supplied have all facilitated multinational cooperation and helped in drawing up multilateral technical and regulatory standards (see Pogorel 1994). Now, it can be both legally possible and economically viable to offer communications services without making agreements on and using common standards. It should be taken into account that the lack of common standards certainly increases the uncertainty the potential adopters of new communications technologies and services may face. Commitment to a solid global standardization policy would promote the diffusion of communications technologies and facilitate intra-national co-operation among the enterprises.

The standard setters certainly face a challenging task and may not always end up with the best possible standard solutions. Another problem which may arise in the standard setting is that sometimes society's welfare maximizing target differs from policy makers' preferences and their personal objectives. Blankart and Knieps (1995) underline the importance of and need for a control of the standard setters in the network markets. Government agencies or other authorities which have power

to set standards should be restricted to act only under certain market conditions; the regulators are needed only in the case of non-contestable network markets for avoiding undesirable abuse of market power. Additionally, pure competition or many demanders of network services may give rise to inefficiencies in the form of coordination problems due to network externalities on the demand side. Also in these cases, market intervention by the regulatory authority is preferable. When the network market is contestable, government intervention to standard setting is not required, but it may instead, if exercised, result in a rather unfavourable outcome: regulatory authorities may maximize their own power or budget instead of maximizing overall welfare.

Also Faulhaber (1995) raises doubt on the policy makers' willingness to make welfare maximizing decisions from the society's point of view. He considers the public policies exercised in the US telecommunications markets throughout its history. He points out that the regulators are often reluctant against changes that alter a status quo and then may possibly also reduce their own power. In telecommunications markets, this has meant a considerable delay in the competitive process. Consequently, as competitive markets offer a wider variety of communications products, the consumers have suffered from the loss of benefits (or delay for achieving these benefits) due to the regulatory actions of telecommunications authorities.

3.4.4 Other possibilities to facilitate diffusion

Government investments in communications infrastructure has been of fundamental importance in the diffusion of communications technologies. Government still plays a crucial role in the development of information infrastucture but now it has been widely agreed that the government's role is chiefly to support and encourage private investments; the private sector should assume the main responsibility for the development and maintainance of information and communications infrastructures (see, e.g. OECD 1996). When the infrastructure for the use of advanced communications systems is available but the new communications technologies are not widespread and probably underutilized in a society, public ICT procurement might facilitate wider diffusion of new communications systems. Besides, the adoption and use of advanced communications systems is also likely to increase the efficiency of the public sector. Public investments in ICT in schools and universities can also be used as a means to support the training of the users of ICT. Publicly provided courses may provide some basic skills to use ICT, but it seems likely that they fail to give firm–specific strategic abilities to utilize new communications technologies (see Preißl 1995).

Governments can also play a critical role in the ICT diffusion process by removing the obstacles which complicate the international trade of communications technologies. Government actions for opening up a country to trade and foreign investments can accelerate considerably the diffusion of

information and communications technologies in certain countries - especially in those which chiefly import ICT sold in their domestic market. For instance in India and Columbia, the general decrease in custom duties has been a prominent stimulus for the rapid diffusion of information technology (OECD 1996).

The effects of different technology policy means, which aim at facilitating the spread of ICT, on the diffusion of ICT and on overall welfare may also critically depend on the market structure on the supply side of the ICT market. The study of Stoneman and David (1986), for instance, suggests that subsidies and information provision policies may have different implications for the adoption of new technologies depending on whether the technology is provided by monopoly or by the competitive market.

In general, as the market for new communications technology embraces a great many uncertainties, governments may have a significant effect on the spread and utilization of new communications technologies via the expectations the practiced technology policy generates. Then, it is important – irrespective of the means the policymakers use – that the government is able to commit itself to the practiced technology policy and to create a sufficiently reliable environment for entrepreneurial investments in new information and communications technologies.

Before we conclude this section, we may note that the early adoption and a rapid diffusion of a new technology do not necessarily maximize the welfare of a certain country in the long run. We can find examples indicating that being late in the adoption of a new technology may sometimes appear to be an advantage to a country rather than disadvantage (see Antonelli 1993, Van der Krogt 1996). The late adopters of technological innovations may benefit remarkably from the experience of early adopters and from the further technological improvements of a certain technology. This has been the case, for instance, in the late development of telecommunications infrastructure – after the introduction of digital technology in switching systems – in the less developed countries (see Van der Krogt 1996).

3.5 Conclusions

This paper has highlighted some crucial factors at the demand side of the ICT market which justify and stress the importance of government intervention in the diffusion of new communications technologies. The presence of network externalities and uncertainties are the two essential sources of inefficiencies on the ICT market which give rise to the need for government actions. In addition, the ICT market comprises some other sources of market failures – like information asymmetries – which give further prominence to the practiced technology policy on the ICT market.

The specific features of the ICT market suggest several potential ways to encourage and facilitate the spread of new communications technologies. It may be reasonable to subsidize the early adopters of new communications technologies in order to speed up the network formation and to ensure that a communications

network does not collapse in its early phases just due to a too small installed base of users. As new communications technologies typically require a substantial amount of learning before they can be fully utilized, it is important that technology policy does not only induce firms to invest in new technologies, but also to train their staff to strategically utilize these technologies.

Uncertainties regarding new communications technologies and networks can be reduced by using public information provision programmes. Information provision programmes can also be used as a means to reduce undesired consequences of information asymmetries. Uneven spatial diffusion of new communications technologies indicates that information regarding new communications technologies should be targeted especially to remote areas. Also technical standards are important in reducing uncertainty and in ensuring the maximum exploitation of network externalities in the networks.

Even if the need for government actions on the ICT market seems evident, it is far less clear how efficient the different policy means are and how their efficiency varies with divergent techno-economic conditions. Also, it remains uncertain what the order of magnitude of the external support the ICT market requires for new communications technologies to spread along an optimal diffusion pattern is. A successful practice of technology policy on the ICT market requires answers to such crucial questions. A strategic assessment of the efficiency of different policy means is thus needed. The effects of the past and the current public programmes and technology policies on the diffusion of new information and communications technologies would then have to be critically evaluated in a cross-national and cross–sectoral comparative perspective.

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Notes

1. For instance, innovative use of ICT in the management of road information systems and in information provision to the users of public transport has potential significance in reducing congestion and improving environmental quality (Nijkamp et al. 1996).

2. A pioneering paper discussing the role of market failures in technological change and the consequent need for public policies in the adoption of innovations was presented by Arrow (1962).

3. See also, e.g. Balcer and Lippman (1984) and Weiss (1994) for studies on the role of technological expectations in the adoption of new technologies.

4. See also, e.g. Reinganum (1981) and Stenbacka and Tombak (1994) for modelling the strategic behaviour and the diffusion of new technologies.

5. The entrepreneurial investment strategy depends also on the form of new communications technology, i.e. on the business and communications purposes a technology serves.